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1.	Your reference	AJF/CRC60724/000
2.	Patent application number *(The Patent Office will fill in this part)*	14 AUG 2002 0218946.2
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	THERMO ELECTRON CORPORATION 81 Wyman Street PO Box 9046 WALTHAM MA 02254-9046 USA
	Patents ADP number *(if you know it)*	7745866002
	If the applicant is a corporate body, give the country/state of its incorporation	DELAWARE, UNITED STATES OF AMERICA
4.	Title of the invention	DILUTING A SAMPLE
5.	Name of your agent *(if you have one)*	BOULT WADE TENNANT
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	VERULAM GARDENS 70 GRAY'S INN ROAD LONDON WC1X 8BT
	Patents ADP number *(if you know it)*	42001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number (if you know it) / Date of filing *(day/month/year)*
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8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))*	YES

DILUTING A SAMPLE

Field of the Invention

This invention relates to a method and apparatus for diluting a sample before it is tested or analysed, or for any other reason.

The invention is described herein with reference to liquid samples which require dilution before they are analysed in a mass spectrometer. However, the invention is not limited to liquid samples or mass spectroscopy and can equally apply to dissolved or suspended samples and any other test or analysis equipment.

Description of the Related Art

Analysis equipment for analysing trace elements in liquids have a limited capability of measuring samples which contain relatively high levels of dissolved solid material, or matrix (such as $CaCO_3$ or dissolved salts in water, or the like). The trace elements of interest to the user are often only a few parts per billion, or lower, whilst the matrix can be many parts per million, or higher. Such high levels of matrix can have undesirable effects on the analytical equipment, such as deposition of materials on orifices, glassware, or ion optical elements, unless the sample is appropriately diluted.

Inductively coupled plasma mass spectrometers (ICP-MS) typically require a total dissolved solid level of less than 2000mg/l to avoid this swamping. The dissolved solids which are deposited on components within the instrument, for example on the cones which sample the plasma and skim off a portion of the supersonic jet, significantly reduces the reliability of the test result and the results of any other subsequent test. If deposition of materials occurs, the instrument has to be thoroughly cleaned before

accurate testing can resume.

Test laboratories are often required to analyse many samples quickly where the matrix content of each sample varies widely. Typically, the user would wish to dilute each sample by a certain amount to determine the analytes present in each sample, and whether the sample can be analysed undiluted. If dilution is required, this initial test provides an indication of the dilution factor necessary to bring the total dissolved solids down to a level tolerated by the instrument.

Such manual intervention is too cumbersome, time consuming and costly if many samples per day require analysis. Presently, samples which introduce too great a loading of dissolved solids for the instrument to cope with are re-analysed once the analyser has been cleaned. Analysis must cease for instrument cleaning, and samples inadvertently analysed after contamination has occurred must be re-analysed. These additional steps require considerable operator intervention. Such a limit to the throughput of samples is undesirable and operator intervention is costly.

Automated dilution systems have been used previously and, referring to figure 1, such an automated system 10 known in the art is shown in highly schematic form. A sample 12 is drawn from a container by a sample pump 14 to a mixing tube 16. Similarly, a diluent 18 is drawn by a diluent pump 20 to the mixing tube 16 from a separate diluent container. The sample is diluted in the mixing tube where it is completely mixed with diluent. An instrument pump 22 draws the diluted sample from the mixing tube and into the instrument or analyser, not shown in figure 1.

Both the sample and diluent pumps have to be able to maintain accurately flow rates to ensure the sample is diluted precisely. If the dilution is not

maintained to a known level and within a relatively tight tolerance, the accuracy of the analysis results may be unacceptable. Likewise, the instrument flow must be maintained at an accurate flow rate to ensure the diluted sample is pumped to the analyser's input at a known, controllable rate. Thus, all the pumps (and their associated flow rates) need to be controlled accurately to maintain accurate test results.

Presently, peristaltic pumps are used to pump the sample, diluent and diluted sample through the dilution system. Typically, dilutions ratios of 50:1 of diluent to sample are used for mass spectroscopy. Hence, the diluent pump rate is typically fifty times greater than the sample pump rate. Peristaltic pumps have a limited range of flow rates and the sample and diluent pumps often operate at the extremes of their flow rate range. Also, the limited flow rate for peristaltic pumps limits the dilution factor by which the sample can be diluted.

The rate at which the diluted sample enters the instrument (not shown) depends on the type of instrument being used but is relatively low and typically a few millilitres per minute. Typically, the combined flow rates of the sample and diluent pumps exceeds the instrument pump flow rate. This is because all the pumps have a relatively similar range of flow rates in which they can operate. Thus, for example, at dilution factors greater than ten, the dilution pump 20 must be operating at a high flow rate which typically exceeds the acceptable flow rate of the analysis instrument. It is, therefore, necessary to provide a waste outlet 24 to prevent build up of pressure in the system; excess diluted sample not pumped to the instrument flows to a waste container 26. At high dilution factors, the solution flowing to waste can exceed the solution entering the analyser by

as much as a factor of fifty. Materials in the waste container are discarded and, since high quality diluent necessary for accurate test results is relatively expensive, this wastage is an additional economic burden on test laboratories.

Other types of pumps, such as syringe pumps can also used. Syringe pumps require the syringe to draw up the fluid (be it the sample or diluent) before it is pumped to the analysis instrument. A series of valves is therefore required to ensure the correct flow of fluid through the system. The additional time required to draw the fluid into the syringe limits the laboratory's (or analysis instrument's) ability to test many samples over a period of time. Furthermore, the time required to control the valves further limits the throughput of test samples, and extra control algorithms may be necessary for the system controller to control the values, further increasing system complexity.

Pumping systems similar to the ones described above are disclosed in US 4,245,509 (Instrumentation Laboratory Inc.) and US 5,007,297 (Pacific Scientific Company).

Another automated pumping system 28 known in the art is shown in figure 2 in highly schematic form. Sample 29 is pumped along a first pipe 30 by a syringe pump 31 to fill the syringe (not shown). A valve 32 is closed to prevent fluid entering the syringe from the pump discharge pipe 33. When the pump is charged with an appropriate amount of sample, the valve is opened and the syringe plunger driven at a constant rate to provide a flow of sample along pipe 33 in the general direction indicated by arrow Z. A one way valve in the pump (not shown) prevents the sample from flowing back to the container 29 during the phase sample flow along pipe 33.

A mixing region 34 of the pipe is defined by a

second pipe 35 adjoining pipe 33 in a generally "T" or "Y" shaped configuration. As solution is aspirated by the instrument pump system (for example, nebuliser), an uncontrolled pressure drop is produced in pipe 35. This causes an uncontrolled flow of solution along pipe 33' from the mixing region 34. This flow rate is a combination of a controlled flow of solution from the syringe pump, and an uncontrolled flow of diluent along pipe 35. The inability to control the flow of diluent results in an uncontrolled dilution factor. There is no instrument pump to pump the diluted sample to the analyser in this arrangement.

Problems arise with systems which rely on this arrangement. For instance, there are limits to the dilution factor this system can provide, especially if the analyser requires the diluted sample to be pumped at a specific rate. This problem could be overcome by providing an instrument pump and pressure relief system, similar to that shown in figure 1. However, the problems associated with the system in figure 1 now become prevalent with this system, for example, diluent wastage.

Summary of The Invention

It is an aim of the present invention to ameliorate the problems associated with the prior art.

More specifically, there is provided a dilution system for diluting a sample for analysis by an analyser, comprising a first pump means, a second pump means, a diluent for diluting the sample, a mixer for mixing the sample and diluent, a first pipe disposed between a sample container and the mixer, a second pipe disposed between a diluent container and the mixer, and a third pipe disposed between the mixer and the analyser, wherein the first pump means is arranged to pump the sample or the diluent at a first or second flow rate along the first or second pipe respectively,

to the mixer, the second pump means is arranged to pump the diluent or diluted sample at a second or third flow rate along the second or third pipe to the mixer or analyser respectively, and the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates respectively.

There is further provided a pumping system for pumping a diluted sample to an analyser for analysis, comprising a first pump means for pumping the sample or a diluent through a first or second pipe at a first or second flow rate respectively, to a mixer, a second pump means for pumping the diluent or a diluted sample at the second or third flow rate through the second or third pipe to the mixer or the analyser respectively, the mixer being arranged for mixing the sample with a diluent for dilution of the sample, wherein the first pipe is disposed between a sample container and the mixer, the second pipe is disposed between a diluent container and the mixer, and the third pipe is disposed between the mixer and the analyser; and wherein the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates respectively.

There is yet still provided a method for diluting a sample prior to analysis in an analyser, using a pump system comprising a first pump means for pumping the sample or a diluent along a first or second pipe at a first or second flow rate respectively, to a mixer, a second pump means for pumping the diluent or a diluted sample at the second or third flow rate along the second or third pipe to the mixer or the analyser respectively, the mixer being arranged for mixing the sample with a diluent thereby diluting the sample, the first pipe is disposed between a sample

container and the mixer, the second pipe is disposed between a diluent container and the mixer, and the third pipe is disposed between the mixer and the analyser; the method comprising the steps of; a) mixing the sample with a diluent in the mixer to dilute the sample; and b) pumping the diluted sample to the analyser at the third flow rate; wherein the third, second or first rate respectively, is substantial equal to the difference between the second and first, third and first, or third and second flow rates respectively.

The embodiments have an advantage of reducing system complexity, increasing dilution factor range over which the system can operate acceptably, increasing sample throughput, and decreasing operator intervention.

Embodiments of the present invention have a further advantage of a reduced number of pumps required to dilute the sample accurately before it is analysed with a substantial improvement to the range of dilution factors. The pump system and the dilution factor can be more easily controlled to better accuracy levels. The time taken to change samples for dilution is greatly reduced using embodiments of the present invention, thus increasing the number samples which might be tested by an analyser. Also, virtually no diluent is wasted during normal operation.

A further aspect of the present invention resides in the method further including: i) replacing the sample container with the another sample container containing a second sample: ii) varying the first rate to substantially the third rate for a predetermined time; and iii) after the predetermined time, reducing to first rate so that the sample is diluted by a dilution factor; wherein the predetermined time is substantially the time taken for the second sample to be transferred from the another container to the mixer

at the first rate.

This further aspect has the advantage of substantially reducing the time taken to exchange samples for dilution and hence increases the number of samples which can be tested or analysed over a given time period.

The present invention provides an additional method for diluting a sample, using a pump system comprising, a first pump means, a second pump means, a diluent for diluting the sample, a mixer for mixing the sample and diluent, a first pipe disposed between a sample container and the mixer, a second pipe disposed between a diluent container and the mixer, and a third pipe disposed between the mixer and the analyser, the first pump means being arranged to pump the sample or the diluent at a first or second flow rate along the first or second pipe respectively, to the mixer, the second pump means being arranged to pump the diluent or diluted sample at a second or third flow rate along the second or third pipe to the mixer or analyser respectively: the method comprising; a) pumping the diluted sample between the mixer and the analyser at the third rate; b) pumping the sample at an initial rate for a predetermined time; c) after the predetermined time, reducing the initial rate to the first rate; and d) mixing the sample with a diluent to dilute the sample; wherein, the initial rate is substantially the third rate, the predetermined time is the time taken for the sample to be transferred from the container to the mixer at the initial rate, and the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates respectively.

Embodiments of the invention have further advantages of substantially reducing the operator intervention, and increase the sample throughput rate. The embodiments aim to provide automated dilution of the sample at a consistent and safe level before the sample is introduced into the analyser. Dilution of the sample to a safe level also has the advantage of allowing the required precision of analysis to be carried out on trace levels within the sample by automatic dilution of the sample. The sample throughput can also be increased by a relatively rapid introduction of new (or different) sample solutions up to the mixing region by controlling the flow rate of the sample uptake. The cost of diluting samples can be reduced by reducing the amount of diluent used by the dilution system; only the volume of diluent required to dilute the sample to a required safe level can be consumed and little or no diluent is wasted. (By 'safe level', we mean a dilution factor necessary to avoid contamination of the analysis instrumentation.)

Detailed Description of An Embodiment

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a pump system known in the art and described above;

figure 2 is a schematic diagram of a pump system known in the art and described above; and

figure 3 is a schematic diagram of another pump system embodying the present invention.

Referring to figure 3, a pump system 50 embodying the present invention is shown in schematic form. A sample 52 to be analysed is drawn from a container by a first pump 54 along a first pipe 56 to a mixing section 58. The end of the first pipe at which the

sample enters the system is completely submersed in the sample to ensure no air enters the system. At the mixing section, the first pipe 56 is joined to a second pipe 60 to form a single pipe 62.

The mixer is a "Y" or "T" configured junction in the tubing or pipes. Other, more complex arrangements of pipe joints might be used which ensure thorough mixing of the fluids entering the mixing region from the first and second pipes. The exit of the mixing section comprises a single pipe 62 disposed between the mixing section and a second pump 64 which pumps fluid from the mixing section to an instrument (not shown) for analysis.

Mixing of the sample and diluent to form a diluted sample takes place at the interface of the first, second and third pipes. Additional mixing also occurs for some length along the third pipe from the mixer to the analyser. Mixing occurs as a function of the turbulent flow of the sample and diluent at the junction and along the third pipe, and also by diffusion of the two fluids. In this embodiment, mixing may also occur as the fluid passes through the second pump on the third pipe, particularly if the second pump is a peristaltic pump.

The first pump is preferably a piston type pump, similar to the milliGAT pump head supplied by Global FIA Inc.(described in US6,079,313). This type of pump allows a much greater range of flow rates, compared to peristaltic pumps for instance, and can operate to continuously pump relatively large or small volumes of sample at a constant, or varying flow rate, as desired. Furthermore, this type of pump can operate at very low flow rates (typically in the region of micro litres per minute) with the accuracy and precision required for this application. This piston pump system does not suffer the disadvantages associated with the prior art systems described previously. The

second pump may be the same type as the first pump, or, if appropriate, may be a (much cheaper) peristaltic pump.

A diluent 66 is drawn from a diluent container 67, up the second pipe 60 to the mixing section 58 where it mixes with the sample, and hence dilutes the sample. The end of the second pipe at which the diluent enters the system is completely submersed in the diluent to ensure air does not enter the system. The flow from the mixer to the instrument of the diluted sample is accurately controlled by the second pump 64 at Flow 3; the second pump is also controlled by the controller 55. Thus, when Flow 1 < Flow 3, the diluent is drawn along the second pipe 60 to the mixer at a flow rate Flow 2, following the equation

$$Flow\ 1 + Flow\ 2 = Flow\ 3 \quad ;$$

assuming the liquids in the pipes are non-compressible. (The flow can be measured in litres per minute).

Preferably, Flow 3 is kept constant by the second pump 64, hence the rate of arrival of diluted sample of the instrument is constant. Varying the flow rate of the first pump therefore changes the dilution factor D by which the sample is diluted, where

$$D = Flow\ 2\ /\ Flow\ 1 \qquad\qquad ,\text{or}$$
$$D = (Flow\ 3\ /\ Flow\ 1) - 1.$$

So, from the equations above and assuming Flow 3 is constant, a decrease in the first pump's flow rate (*Flow 1*) increases the diluent flow to the mixer section, and hence the dilution factor D.

An example of how the pump system embodying the invention can operate with an ICP-MS instrument is now provided. During operation, all samples are routinely

diluted by a discrete dilution factor D_1 before the sample is analysed. D_1 is initially set to a relatively high level so that the sample is diluted to such an extent that any dissolved solids (or matrix) in the sample are sufficiently diluted when the sample is analysed. In this way, adverse effects to the analysis instrumentation or the test result can be prevented or reduced. Typically, $D_1 = 100$.

Analysis software which checks the analyser results determines the extent of diluted matrix in the sample, to see whether further dilution is necessary. Also, the analysis data, or results are processed to determine the precision of the measured analyte signal. This data can be fed to the controller 55 for real time adjustment of the dilution factor, depending on the analysis results. For instance, if the analyte signal is too weak, the dilution factor may need to be reduced. Moreover, the instrument may not be able to measure analyte concentration with the required accuracy if the analyte signal is too intense (in which case the sample may require further dilution by a factor D_2). Flow rate information or data can be passed from the pumps (or any flow meters - not shown) back to the controller for use by the controller.

Therefore, it is possible for the controller to change the dilution factor (if necessary) having regard for the analyser results. For example, if the results show too much matrix remains in the diluted sample for accurate analysis, the controller can reduce the first pump's flow rate, thereby increasing the dilution factor, as described previously.

D_2 can be calculated by comparing the matrix signal from the analyser with a pre-determined maximum level used for providing adequately accurate results. As previously described, the new dilution factor D_2 is achieved by adjusting Flow 1 of the first pump 54. As a result, the dilution factor can be controlled in

real time as analysis results are made available from the analyser. Thus the throughput of the instrument can be greatly improved and less intervention from a human operator is required. Furthermore, if the dilution factor is maintained at a relatively high level, the inlet of the analyser can be prevented from becoming contaminated with matrix materials, thus reducing the downtime necessary for cleaning the instrument.

When a new, or different, sample is required for analysis the first pump 54 pumps the new sample from a container at a rate just less than, or substantially equal to, Flow 3 for a period of T1. The period T1 is calculated so that the new sample completely fills the first pipe from the mixer 58 to the first pump 54, using the equation

$$T1 = V/(Flow\ 1)$$

where V is the volume of the tubing 56 from the sample uptake to the mixer, including any volume occupied by the sample within the first pump 54.

After time period T1 has elapsed the flow rate of the first pump is reduced, thus initiating dilution of the sample by a dilution factor, as previously described. The time taken for the diluted new sample to reach the analysis instrumentation can be calculated, knowing the volume of pipe from the mixer to the analysis instrument, including any volume occupied by the diluted sample in the second pump 64. Hence, the instrument can be programmed to start the analysis of the new sample only when the pump system has 'purged' itself of any previous samples which may have remained in the pumps or tubing.

In an alternative embodiment, the second pump is disposed between the diluent container and the mixing region. In this embodiment, the pump controller is

capable of finely balancing the flow rate of each pump so that the flow of fluid to the analysis instrument remains constant. During the sample change over, or purge procedure described above, the instrument (or diluent) pump can be stopped until the new sample has been pumped to the junction in the mixer, at which point the diluent pump rate can be rapidly ramped up so that the new sample is diluted and pumped to the analyser for analysis. At the same time, the first flow rate is reduced so as to keep the flow to analyser constant.

A further embodiment includes an arrangement where the first pump is disposed on the second pipe with the second pump being between the mixer and the analyser.

Another embodiment is provided by an arrangement where a single pump is disposed between the mixer and analyser and one, or both of the flow rates in the first or second pipe is controlled by at least one valve, or variable constriction. The valve, or valves, can be controlled by the pump controller, or a separate valve controller in communication with the pump controller.

The pump systems described above are in a 'closed' configuration, by which we mean the sample and diluent are contained in the system from the input to the output; there is no waste pipe (as provided by the prior art). By keeping the system closed the equations above are maintained during operation. It is therefore important to make sure the diluent and the sample do not run out during operation to prevent air entering the system.

The tubing or pipe components of the pump system 50 should be made of suitably rigid materials to prevent expansion or contraction under any pressure. Such expansion or contraction is undesirable since it effects the volume V occupied by the sample, diluent

and diluted sample. The expansion and contraction can be tolerated if their extent is determinable or predictable.

The mixer should preferably be designed to ensure full mixing of the sample and diluent by creating a turbulent flow in the mixing region of the pipe.

The first and second pumps should provide a substantially continuous flow, without any pulsing. The flow rate from each pump can be determined by using independent flow meters disposed fore or aft of the respective pump, with an appropriate feedback loop to the pump controller. Alternatively, the dilution factor can be measured using an internal standard. An appropriate software programme can be used by the controller to automate the dilution of the samples and change-over from one sample to the next, as described above. The controller might comprise a desktop PC with appropriate input and output devices to monitor and control the pumps, using an appropriate software programme.

Embodiments of the present invention can be used with an automated sample dispenser, or the like. Furthermore, embodiments can be used with any type of analysis instrumentation, such as a chromatographic instrument.

Examples of samples used by embodiments of the present invention include drinking water, waste water, sea water, dilute acids, urine, blood, spinal fluid, dissolved solid or gaseous samples, or the like. These examples are by no means exclusive, and any liquid sample which requires analysis can be diluted prior to entering the analyser by a system which embodies the present invention. Of course, an appropriate diluent is required for different samples and the choice of diluent for a given sample does not form part of the present invention. The diluent may be de-ionised water, ethanol or the like, but whatever is

most suitable depending on the sample being analysed.

Further embodiments of the present invention will be envisaged by the skilled person. For example, the embodiments have been described using in-line pumps, but it may be desirable to use other pumping systems.

CLAIMS

1. A dilution system for diluting a sample for analysis by an analyser, comprising

a first pump means,

a second pump means,

a diluent for diluting the sample,

a mixer for mixing the sample and diluent,

a first conduit disposed between a sample container and the mixer,

a second conduit disposed between a diluent container and the mixer, and

a third conduit disposed between the mixer and the analyser,

wherein one of the pump means is arranged to draw sample along the first conduit for passage through the mixer,

the other of the pump means is arranged to draw diluent along the second conduit for passage through the mixer, the pumps being arranged so that the flow rate of diluted sample along the third conduit is substantially the sum of the flow rate of diluent along the second conduit and the flow rate of sample along the first conduit.

2. A pumping system for pumping a diluted sample to an analyser for analysis, comprising

first pump means for pumping the sample through a first conduit at a first or second flow rate to a mixer,

a second pump means for pumping the diluted sample at a second flow rate through the third conduit to the analyser,

the mixer being arranged for mixing the sample with a diluent for dilution of the sample,

wherein the first conduit is disposed between a sample container and the mixer, the second conduit is

disposed between a diluent container and the mixer, and the third conduit is disposed between the mixer and the analyser; and

wherein the third, flow rate is substantially equal to the sum of the second and first flow rates.

3. A system according to claim 1 or 2, further comprising a pump controller for monitoring and/or adjusting the first or second pumps during operation.

4. A system according to claim 3, wherein the controller is a PC, and

the controller is arranged to receive data from the analyser for real time adjustment of the pumps.

5. A system according to claim 1 or 2, wherein the mixer comprises two or more input tubes, a mixing portion and an exit tube,

a first input tube being arranged for communicating the sample to the mixing portion,

a second input tube being arranged for communicating the diluent to the mixing portion.

6. A system according to any preceding claim, wherein the third rate is substantially equal to, or greater than, the first rate, and a dilution factor is determinable by the ratio of the first and second rates.

7. A system according to claim 1 or 2, wherein the second pump means is arranged for substantially constant flow and the dilution factor can be adjusted by varying the first rate.

8. A system according to claim 2, wherein the first pump means is disposed on the second conduit, or the second pump means is disposed on the second conduit.

9. A system according to claim 1 or 2, wherein the analyser is a mass spectrometer.

10. A system according to any preceding claim, wherein the first and/or second pump means comprises a piston pump.

11. An analyser for analysing a sample, comprising a pumping system according to any preceding claim.

12. An analyser according to claim 11, wherein the analyser is a mass spectrometer.

13. A method for diluting a sample prior to analysis in an analyser, using a pump system comprising

a first pump means,

a second pump means,

a diluent for diluting the sample,

a mixer for mixing the sample and diluent,

a first conduit disposed between a sample container and the mixer,

a second conduit disposed between a diluent container and the mixer, and

a third conduit disposed between the mixer and the analyser,

wherein one of the pump means draws sample along the first conduit for passage through the mixer,

the other of the pump means draws diluent along the second conduit for passage through the mixer,

so that the flow rate of diluted sample along the third conduit is substantially the sum of the flow rate of diluent along the second conduit and the flow rate of sample along the first conduit.

14. A method according to claim 13, wherein the system further comprises a controller for monitoring and/or adjusting the first or second pumps, or their

respective flow rates, and

wherein the flow rates can be adjusted in real time.

15. A method according to claims 13 or 14, wherein the third rate is substantially constant and the dilution factor is adjustable by varying the first or third rate.

16. A method according to claim 13, further comprising,

when another sample requires dilution, the additional steps of;

i) replacing the sample container with the another sample container containing a second sample;

ii) varying the first rate to substantially the third rate for a predetermined time; and

iii) after the predetermined time, reducing to first rate so that the sample is diluted by a dilution factor;

wherein the predetermined time is substantially the time taken for the second sample to be transferred from the another container to the mixer at the first rate.

17. A method for diluting a sample, using a pump system comprising,

a first pump means,

a second pump means,

a diluent for diluting the sample,

a mixer for mixing the sample and diluent,

a first conduit disposed between a sample container and the mixer,

a second conduit disposed between a diluent container and the mixer, and

a third conduit disposed between the mixer and the analyser,

the first pump means being arranged to pump the sample or the diluent at a first or second flow rate along the first or second conduit respectively, to the mixer,

the second pump means being arranged to pump the diluent or diluted sample at a second or third flow rate along the second or third conduit to the mixer or analyser respectively:

the method comprising;

a) pumping the diluted sample between the mixer and the analyser at the third rate;

b) pumping the sample at an initial rate for a predetermined time;

c) after the predetermined time, reducing the initial rate to the first rate; and

d) mixing the sample with a diluent to dilute the sample;

wherein, the initial rate is substantially the third rate,

the predetermined time is the time taken for the sample to be transferred from the container to the mixer at the initial rate, and

the third, second or first flow rate respectively is substantially equal to the difference between the second and first, third and first, or third and second flow rates respectively.

18. A computer program which, when run on a computer, carries out the method according to any of claims 13 to 17.

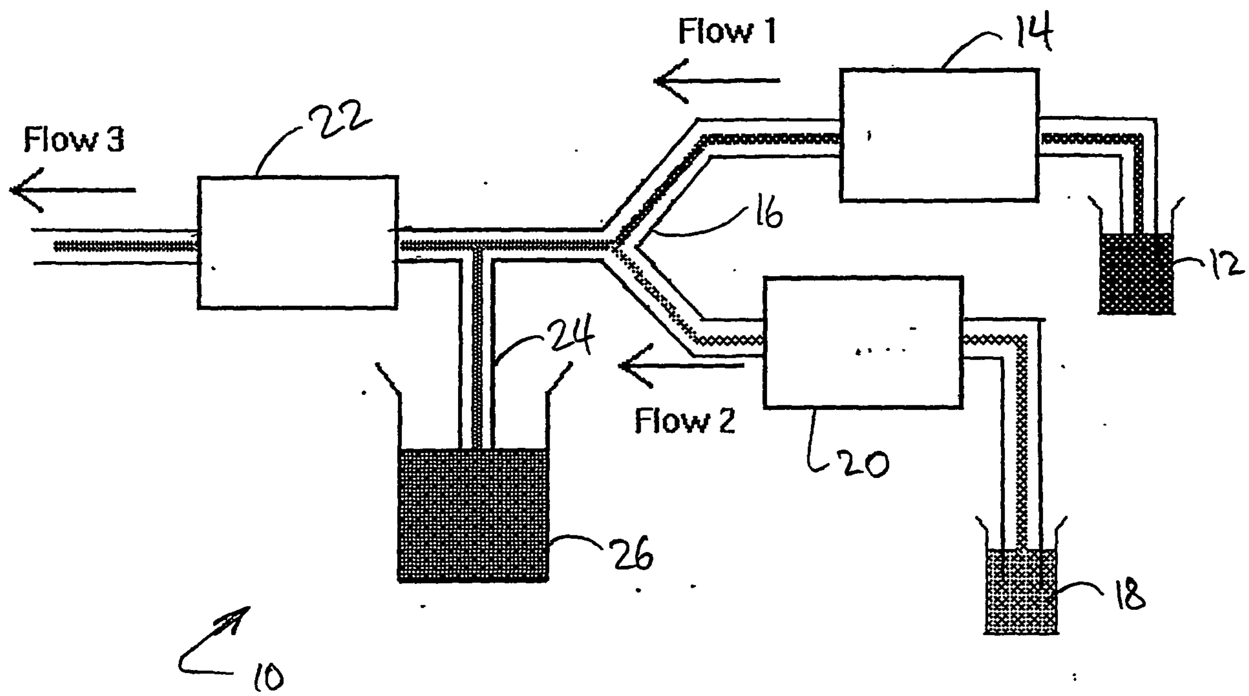
19. An electronic carrier means on which is stored the computer program according to claim 18.

20. A dilution system, substantially as herein described, with reference to figure 3 of the accompanying drawings.

21. A method for diluting a sample, substantially as herein described, with reference to figure 3 of the accompanying drawings.

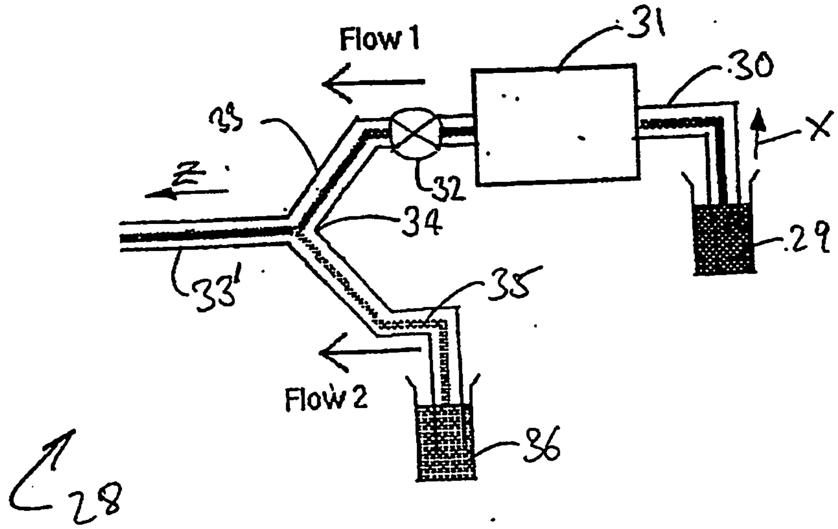
22. An analyser, substantially as herein described, with reference to figure 3 of the accompanying drawings.

: 156780: CRC: CRC: READDOCS



PRIOR ART

Figure 1



PRIOR ART
Figure 2.

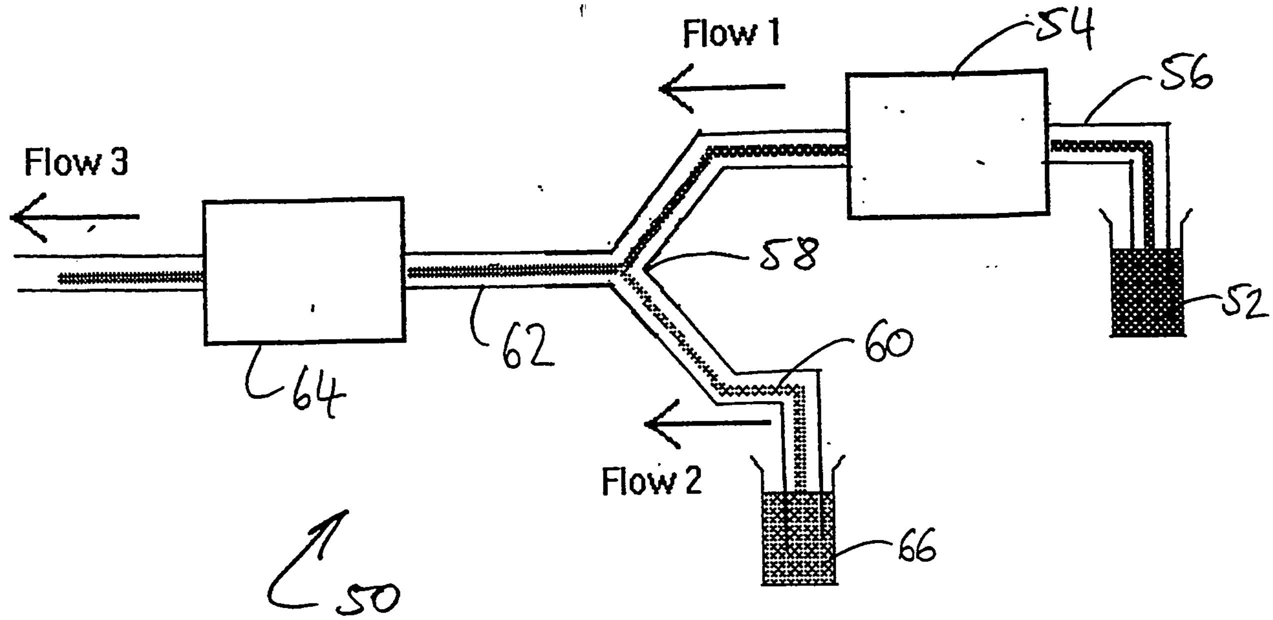


Figure 3.